TOMLINSON BRIDGE
(State Bridge No. 00337)
Spanning the Quinnipiac River at Forbes Street (U.S. Route 1)
New Haven
New Haven County
Connecticut

HAER No. CT-61

PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

HISTORIC AMERICAN ENGINEERING RECORD
National Park Service
Northeast Region
U.S. Custom House
200 Chestnut Street
Philadelphia, PA 19106

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HISTORIC AMERICAN ENGINEERING RECORD

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(State Bridge No. 00337) HAER NO. CT-61

Location: Spanning the Quinnipiac River on Forbes Avenue (U.S. Route 1), New Haven, New Haven County, Connecticut.

UTM: 18.675500.4573800
Quad: New Haven, Connecticut 1:24,000

Date of Construction: 1922-1924

Designer/Consultant: Joseph B. Strauss/Ernest W. Wiggin

Present Owner: State of Connecticut
Department of Transportation
Newington, Connecticut 06131

Present Use: Vehicular and rail freight traffic, marine navigation.

Significance: In 1924, an existing swing bridge at this location was replaced by the present trunioned, double leaf bascule bridge. The new bridge was designed to handle vehicular, rail freight and public transport trolley car service. The plans clearly illustrate the claims protected under U.S. patent #1,124,356. Strauss' patented design permitted a low architectural profile which Wiggin finished in the Beaux Arts style. This treatment was in harmony with the nearby Adee (Yale) Boathouse and its original environment.

Strauss went on to have a noteworthy career as a master bridgebuilder. He achieved prominence as a member of the design team and chief engineer for the Golden Gate Bridge at the mouth of San Francisco Bay.

Project Information: This documentation commenced in March, 1993 in accordance with the Memorandum of Agreement by the Connecticut Department of Transportation as a mitigating measure prior to replacement of the bridge with a new vertical lift span.

Mary Dieter & Robert C. Stewart
Historical Perspectives, Inc.
Riverside, Connecticut, May 1993

I. Introduction

The Connecticut Department of Transportation (CONNDOT) is preparing for construction work on the Tomlinson Bridge in New Haven (State Project #92-435). The Tomlinson Bridge carries U.S. Route 1 over the Quinnipiac River, connecting New Haven and East Haven. New Haven was an early and active harbor in the history of Connecticut and the first bridge crossing at this site was in 1797. Adjacent to the bridge ramp on the east bank is the historic Adee Boathouse, erected by Yale University in 1910. (see photocopy of aerial photographs view northeast, circa 1956).

II. Historical Context: New Haven Harbor and the Quinnipiac River

After the arrival of the Europeans, New Haven Harbor and the entrance to the Quinnipiac River began their history of intense public and private use. Even before New Haven was officially named, the colony enacted rules and regulations governing the use and commerce of the harbor, rivers and coastline surrounding the new settlement (Atwater 1877:354).

From the time of the founding of the settlement in 1638 until around 1650, early commercial shipping ventures were numerous but not very successful. Shipping dropped off in the harbor and was essentially nonexistent for almost 100 years. Then in 1750 commercial relations were established with the West Indies and New Haven s maritime commerce began to flourish. Between 1750 and 1775 ships were sent to England, France and Ireland and ties were strengthened between the port and the West Indies. Along with cargo lists and duty payments, the 1764 customs house books also record the sailing of the "Fortune" to the West Indies, the ship owned and commanded by Benedict Arnold. He was apparently very active in local shipping and in early plans for improving the harbor (US War Dept. 1939).

By 1815 there were 100 vessels sailing out of New Haven Harbor actively engaged in overseas commerce. It was also in 1815 when the marine list of the Columbia Register, New Haven reported: "Arrived March 21st. The elegant Steamboat "Fulton", Captain Elihu S. Bunkers, 11 hours from New York, with 30 passengers." [The Steamboat arrives at and departs from Tomlinson's Bridge, at the east end of the City.] (Atwater 1887:356)

The arrival of the Fulton heralded the beginning of the sometimes tumultuous steamboat trade in the city. Many companies were formed and ran the route between New Haven and New York. The commercial contacts with the West Indies brought wealthy families from there to New York and then by steamboat to New Haven. The city became a popular vacation spot, and hotels, wharves and "pleasure grounds" were built along the waterfront south of Tomlinson Bridge to accommodate the passengers (Atwater 1887:302). The wharf built off the channel causeway of the Tomlinson Bridge in 1817 became the new location for the Fulton and United States steamboats. It was the first and remained the only wharf connected to the bridge until about 1840 when the Belle Dock was built on the south side of the bridge off the west causeway.

Around 1841-1842 competition for postal contracts, railroad contracts, and the passenger traffic between New Haven and New York became fierce and attempts at monopolizing the routes were made. Tempers apparently ran high and "Commodore" Cornelius Vanderbilt, then head of the Connecticut River Steamboat Company, had his ships ramming ships belonging to competing lines. One of the rammed steamboats was the "Belle" of the Citizen's Line, after which the Belle Dock is named. Vanderbilt succeeded in sinking at least one ship outside the harbor on the New York-New Haven route, and in 1842 the Citizen's Line was sold to Vanderbilt's company. Steamship passenger service was finally discontinued in 1937, and only one freight steamship plied the old route into the 1940s.

As noted above in connection with the steamboat lines, by this time the railroads had also been active in exploiting the harbor. The 1851 Hartley & Whiteford Map shows railroad tracks coming into New Haven from the north, down along East Street and out to the tip of the Belle Dock. A typed notation on the map points to a small structure at the end of the dock "New Haven's first railroad station the Hartford & New Haven, opened in 1839."

Coming from the Quinnipiac River, the east side of the harbor and later from the west side lay the small, but plentiful impetus behind most of the above activity: the oyster. Most of the ships leaving New Haven Harbor for trade with foreign ports carried bushels of this prolific crop. The importance of the oysters and the oyster beds was recognized fairly early. The Oysters and Clams Act of the General Assembly, concerning the "Preservation of Oysters and Clams and Regulating the Fishing Thereof", was written in Hartford in 1766. At about the same time New Haven held town meetings prohibiting the use of "a Dragg at any time," and limiting the oyster take from May through September "except on Monday & Tuesday & before Public Commencement" (Osterweis 1953:104). Across the channel in Fair Haven laying out the oyster beds in the first half of the 19th century occupied most of the 1000 inhabitants. The records for 1836 state they took in 20,000 to 40,000 bushels of oysters per year, and the oyster fleet comprised 300 boats.

From 1852 to 1855 three shipyards associated with the oyster harvest reportedly built 4000 tons of shipping each year to help ply the trade (Osterweis 1953:242-243). Oysters were still being shipped out of the harbor in the first quarter of this century. In more recent years, however, any oysters taken from the harbor or surrounding rivers are removed to cleaner waters to filter out impurities and finish growing until harvest time.

The first "Tomlinson's Bridge" was built in 1797 under a charter granted to Isaac Tomlinson and his business associates in 1796. These gentlemen were apparently operating a ferry that ran the crossing between New Haven and East Haven, and a new bridge that had been built further up the Quinnipiac had taken all their traffic.

They built a 27 foot wide wooden bridge off the east end of Water Street. This was a covered wooden truss with a draw section that allowed vessels passage to the settlement of Fair Haven. On April 25, 1798 The Connecticut Journal announced, "The subscriber is happy to inform the public that a bridge from New Haven to East Haven is passable for foot passengers. A box will be placed at Mr. Woodman's store and the toll will be left to the generosity of those gentlemen that walk over the bridge." (New Haven Colony Historical Society [NHCHS]/Dana, Vol. 56) The bridge was partly destroyed and reconstructed in 1807. Several later drawings, paintings and photographs show the Tomlinson Bridge as a covered bridge (NHCHS/Dana Vols. 52,56; NHCHS 1976:51). There is no record of the entire structure being replaced, but the covered segment was built in 1842 (NHCHS/Dana Vol.52).

The value of the location of the bridge and its adjacent docks had been recognized early on by the railroads, and the Hartford & New Haven Railroad Company owned the majority of the Tomlinson Bridge Company stock by the mid-1800s. It passed its shares to the New York & New Haven Railroad Company in 1872 (Atwater 1887:354). In 1885 the Connecticut general assembly ordered the bridge company to replace the "venerable one that had so long remained there" (NHCHS/Dana Vol. 56), and by December 1, 1885 the wooden bridge had been demolished and an iron bridge put in its place. This particular iron bridge proved to be less than satisfactory, however, as it was one the railroad company had recovered from a Stratford, CT scrap yard. It had been in service across the Housatonic in 1883, and its construction was considered old even at that time (NHCHS/Dana Vol. 56, New Haven Register 1887). The Tomlinson company continued collecting tolls until New Haven voted for funds to take control and modernize the bridge. The city assumed ownership in 1887, but a new span was not planned until 1913.

By 1893 trolley lines had been laid across the bridge. And "major new load requirements came in the early twentieth century when the Manufacturers Railway secured the right to use the bridge; [they] ran full-scale, fully loaded railroad freight cars over the bridge" (State of Connecticut 1990:#337:2). (see photograph of rail and section of bascule deck and photograph of rails and bascule deck at break between east and west leafs).

By 1913 the Tomlinson Bridge was opened more than 17,000 times a year and was considered insufficient in width and sidewalks. New Haven engineer Ernest W. Wiggin was hired to draw plans for a new bridge but it was not realized until after World War I. Construction of the extant double-leaf bascule span, 1921-1924, entailed erection of a temporary bridge, again wooden (Sanborn 1923-1930).

The engineers, designers and builders are commemorated by three bronze plaques. These are located on the storehouse and the south and north sides of the western approach wall. (see photographs of bronze dedication plaques located on storehouse, east abutment; north side at outermost end of western approach wall and engineers/inspectors plaque located on south side of western approach wall).

III. Physical Description

The Tomlinson bridge is located on U.S. Route Number 1 (Forbes Avenue) over the mouth of the Quinnipiac River in New Haven, Connecticut on a principal artery for the city of New Haven and the New England coastline. The State of Connecticut assumed ownership of the bridge on August 31, 1941. In addition to vehicular traffic, the bridge provides a freight railroad switching route between adjacent yards of the Consolidated Rail Corporation (Hardesty & Hanover 1990:6).

The bridge is classified as a trunioned, double leaf, underneath counterweight, closed pit bascule bridge (Hool and Kinne 1923:25). Architecturally, it is trimmed in the Beaux-Arts style. The original operator's house featured a hip roof with a cyma profile and a segmental arch over the door (Derryl Lang, personal communication May 27, 1993). The house was molded in reinforced concrete suffused with one-half inch aggregate. After the forms were removed, the aggregate was exposed by rubbing the surface with Corundum (Wiggin 1916:35). While the original operator's house has been destroyed, a matching structure located on the eastern bascule pier still exists.

The City of New Haven launched plans to replace the second Tomlinson bridge (1885-1922) during World War I. The objective was to design a bridge combining vehicular, public transport, rail freight and navigation requirements. The project produced a composite bridge design to span the 1000 foot wide Quinnipiac River. The crossing consists of a 390 foot fill section which encroaches into the tidal area. In addition there are three fixed symmetrical approaches (see photographs of view northwest, eastern approach, bridge partially open; view northwest, showing 390 foot fill section; view southwest, showing three fixed spans; view north, western fixed sections of bridge; view east, eastern fixed sections of bridge; view southeast, western approach; view northwest, eastern approach). (Regional Planning Agency of South Central Connecticut, New Haven Connecticut [RPASCC] 1984:9-10).

The approach spans consist of eight parallel built-up steel girders with curved bottom flanges. The three spans include two cantilevered spans with a 24 foot suspended section seated on each end of the cantilevers (Hardesty & Hanover 1990:6). Structural girders are encased in a two to three inch thick coating of 'Gunite', a concrete stucco-like coating applied by pneumatic spraying over wire cloth reinforcement that is tack welded to the girder. The main channel is spanned by twin bascule leafs with a center to center distance of 148 feet. The approach and bascule piers are made of concrete with red sandstone exteriors.

The bridge carried 30,000 vehicles each weekday in the mid-1950's before completion of the parallel high level Connecticut Turnpike crossing. A traffic survey in April, 1992 counted 10000 vehicles each weekday passing over the bridge. The bridge opens for marine traffic 3000 to 4000 times each year (Close, Jensen and Miller; Robert Turner, personal communication; May, 1993).

The bridge roadway width is 42 feet and there are 8 foot 5 inch sidewalks on both sides. Sidewalks on the bascule sections are 9 foot 6 inches wide. When closed, clearance over the Quinnipiac River is 12 feet above mean high water. Clearance varies between 8 feet at extreme high water to 17 feet at mean low water (Wiggin 1916:2). At the time of construction, plans called for a channel depth of 20 feet at mean low water. The main channel is 117 feet wide between fenders (Hardesty & Hanover 1990:8).

When it was erected in 1924, the western end of the bridge fronted on the railhead and docks of the New Haven Railroad. Adjacent to the south were the docks of the New England Navigation Company which provided the departure point for daily steamship service to New York City (Wiggin 1916:1 of 36). The eastern approach is overlooked by the Adee (Yale) Boathouse on the north. Today (1993) The northern side of the western approach is a Conrail Yard and the southern side is a Wyatt Oil Corporation tank farm. Tank farms lie to the south (Hardesty & Hanover 1990:6).

The bridge is currently in commission. Besides fulfilling navigational requirements, it carries motor vehicles and supports local railroad traffic between adjacent yards of the Consolidated Rail Corporation. When it was first opened in 1926, it also carried an electric trolley line operated by the Connecticut Company. The line is no longer operational and the trolley arches have been removed (RPASCC 1984:9-10).

The rail system has two tracks having a 4 foot 8 and 1/2 inch gauge. The tracks are twelve feet apart, center to center. Rails are 6 inch X 100 pounds, placed on steel ties that are set on cinder concrete (Wiggin's 21 of 36). The specifications called for an overhead wire electric power supply system that would be compatible with passenger trolleys and rail freight switching engines.

This power transmission system restricted locomotive size. Fifty ton, pre-World War II electric engines which obtained power from overhead trolley lines were limited to towing three to four 170,000 pound cars (car plus load) up a grade generally not exceeding 2.3 percent. These engines would lose traction on steeper grades or with any greater loads. Heavier engines having sufficient traction were available but they could not have been powered from the trolley lines. Engines crossing the bridge must overcome grade, load and inertia. They also start without the benefit of perceptible momentum (RPASCC 1984:14-18). These conditions supported selection of a bridge design which would minimize the approach grades (Hardesty & Hanover 1990:9).

IV. Design Considerations

Three main types of opening bridge were commonly employed in the post World War I period. They were the swing, bascule and vertical lift bridge. Several inventors and designers, notably T.E. Brown, T. Rall, A.H. Scherzer, M. Wadell and J.B. Strauss were active in advancing bascule bridge design (Hool and Kinne 1923:28-29). The Tomlinson bridge is a Strauss design and perfectly exemplifies his underneath counterweight trunion type (see photographs of view northeast, southwest elevation; view north northeast, southwest elevation; view north, bridge closed; view north, bridge partially raised; view north, bridge open).

In 1902 Joseph B. Strauss began developing a series of designs for bascule bridges. Bascule bridges were rare and strictly limited in length at the turn of the century. They were also expensive, primarily because costly cast-iron counterweights were used to counter-balance the bridge deck. Early operating mechanisms were also complicated, unreliable and difficult to maintain.

To lower overall bridge cost, Strauss substituted dense concrete filled with slag or iron punchings for the conventional iron counterweights. The Tomlinson counterweights weigh approximately 234 pounds per cubic foot, (Hardesty & Hanover 1990:7) considerably less than the 311 pounds per cubic foot that Strauss specified (see Strauss' sheet 12 and sketch of operating components). While this alternative greatly reduced cost, it expanded the volume of the counterweight (National Cyclopedia 1959:27:30).

On larger bridges, the bulky concrete counterweights interfered with the supporting structures of bascule designs. Strauss solved this problem by developing a parallel link counterweight system by which the counterweight, its trunion, the main leaf trunion together with their connecting struts, formed a parallelogram. By using this design, which is disclosed in Strauss' patent #738,954, (appendix A) the counterweight is kept in the same relative position during opening and closing of the bridge. The design provides an additional increment of efficiency during movement by maintaining the bascule leaf in a condition of constant balance during operation of the bridge. The parallelogram linkage was first used on a "Heel Trunion" design where the counterweight and its hangers were above the bridge deck.

Later Strauss adapted the parallelogram linkage to an "Underneath Counterweight" design. Strauss also shaped the concrete counterweight to fit between structural elements. The Strauss design utilized open spaces under the bridge deck and between the girders to accommodate the upper portion of the counterweight when the bridge was down. This feature constituted a principal claim of Strauss' patent number 1,124,356, (appendix B).

Utilization of this previously unused space compensated for the increased space requirements of a concrete counterweight. By using this space, the Strauss design could be built about 2 feet lower or closer to the water than competing models. Consequently, given the grade constraints and the required compatibility of freight locomotive and passenger trolley power reception, the selection of the Strauss underneath counterweight design was a reasonable choice.

The Strauss layout also concealed the counterweight and operating mechanism under the roadway, thus producing a graceful, low profile bridge that was amenable to a variety of architectural treatments. A Strauss underneath counterweight bascule design would be unobtrusive and have a minimal visual impact on the surrounding environment.

In addition, there may have been some consideration given to making the bridge aesthetically pleasing and in harmony with the nearby Adee (Yale) Boathouse. The original control house was replaced in 1976 (see photographs of view southwest, control house; view north of 1976 control house and western leaf in closed position) but a storehouse on the eastern abutment (see photograph of typical abutment) remains to show the architectural features of the original matching control room. (see photographs of view south, storehouse on east abutment, detail of cyma roof; view west, storehouse on east abutment). The architectural details are documented as part of this report. (see photographs of decorative architrave which frames the commemorative plate; details of typical balustrade). The low slope approaches would allow continued access to the boathouse from Forbes avenue over its connecting footbridge.

V. Operation

All control functions are performed from a console within the control house on the western abutment. (see photographs of view southeast from control room, with storehouse on eastern abutment; view northeast, control panel for controlling bridge operation). The bascule leafs are raised by means of electric motors equipped with motor brakes. The original lifting machinery was powered by four gearmotors running at 600 rpm. They had a maximum starting torque of 480 pounds and a running torque of 230 pounds. (see photograph of view north, east abutment showing drive gear 'D' in lower center of photograph and racks on center bascule girders 'B' and 'C' at left center; photograph of view south, east abutment showing bascule leaf in raised position with the extreme upper portion of the bascule rack gear showing in the lower right portion of the photograph; photograph of view northwest of rack gears on bascule girders 'B' and 'C').

Power requirements were 550 to 600 volts (see photocopies of Strauss' entire sheet #15 and section of #15). The use of alternating or direct current was not specified on the blueprints. However, the presence of a motor generator implies that utility AC was converted to DC power for the gearmotors. With the existing early 20th century technology, a motor's speed and torque could be readily controlled by using a DC system.

Motive power to lift the spans was originally transmitted through a gear train to pinion gears which meshed with rack gears on the bascule girders.(see photograph of view east showing bascule girders 'A', 'B', 'C' and 'D'; drive gear 'D' with guard is located in the lower center of the photograph. Refer to gearing diagrams depicted on Strauss sheet #15 for power train relationships; see photograph of view west showing bascule girders 'A', 'B', 'C' and 'D'; drive gear 'D' with guard is located in the lower center of the photograph. See photograph of view west, showing 1976 control house and leaf in fully raised position).

Other mechanical and operating details are documented photographically and in photocopies of Strauss' original drawings. (see photograph of view northeast of operating machinery with bascule leaf in closed position - drive gear 'D' is at center of photograph. Note vernacular weight suspended on counterweight at top left of photograph to compensate for an underweight counterweight). (see photographs of view northeast of operating machinery, Gear 'D' is at enter of photograph, emergency brake on the pedestal to the left of center; photograph of east abutment, view northeast of operating machinery - small gear is identified as 'C' - large gear is 'B'; refer to gearing diagrams - Strauss sheet #15 for power train relationships; photograph of view southeast, west abutment of operating machinery - large gear at left center is 'D'; photograph of view southeast, west abutment of operating machinery - bascule leaf raised - large gear at left center is 'D').

The machinery was modified and currently uses a roller chain to transmit power from the motors to the main drive shaft. The original installation used gears exclusively to transmit power (Hardesty & Hanover 1990:8). (see photograph of west side gear-motor with chain drive).

The racks form the lower quadrant of each bascule girder radially to the main trunion.(see photographs of view west, underside of bascule leaf showing structural members and bascule girders with rack gear section; view east, underside of bascule leaf showing structural; members and bascule girders with rack gear section).

The racks have radii of 10 feet 7 inches, centered on the main trunion bearing of each bascule girder (see photocopy of Strauss' sheet #6). The linear dimensions of the bascule girders are 74 feet from the center line of the main trunions to the center line of the span; the distance from the center line of the main trunions to the center line of the counterweight trunions is 12 feet 6 inches.

Bascule girder depth varies from a minimum of 4 feet 2 inches at the center of the span to a maximum of 10 feet 9 and 1/2 inches at the center line of the live load support (see photocopy of Strauss' sheet #6). The bascule leafs pivot on two lines of main trunions that are centered 148 feet apart.

The primary balance weights for the bascule leafs are iron filled cast concrete counterweights formed over and around a steel truss. Pockets were formed in the counterweights and fine balance of the leafs was achieved by adding or subtracting weights contained in these pockets.

The truss provides attachment points for the counterweight trunion bearings and link brackets (see photocopy of Strauss' sheet #11); (see photograph of view of top and front side of east side counterweight - bascule is in raised position, gear 'D' is at right center of photograph; photograph of view east, west abutment, south side - view of rack gear on bascule girder 'D'; photograph of view east inside west counterweight pit - gear 'D' is at center of photograph; photograph of view of a west side counterbalance).

The counterweights pivot on forged steel trunions. Each trunion has two bearing surfaces 10 inches long and 11 and 1/4 inches in diameter. Each counterweight trunion is mounted onto its girder by a cast steel collar on each side of the heels of the bascule girders. The counterweight trunions swivel in cast steel bearings that are faced with 3/4 inch phosphor bronze bushings (Strauss et. al. 1916:17).

Strauss' bascule leaf design was painstakingly counterbalanced. Plans indicate that final counterweight load was to be determined only after the steel components of the bascule were fabricated and weighed. Pockets cast in the counterweight allowed the operator to insert weights and closely adjust leaf balance to compensate for seasonal conditions. With close attention to maintaining leaf balance, power requirements to raise the bridge were minimal. A system of manually operated emergency brakes is provided to lock the leafs in position if there is an electrical or mechanical failure. The brake system, according to the original plans, was designed to be independent of electrical or pneumatic actuation. Gravity, acting on 60 pound counterweights locked the brakes; air pressure, under control of the operator, released them (Strauss et. al. 1916:26).

The bascule leafs consist of four interior variable depth girders connected together with steel plate diaphragms. Girders are built-up riveted and bolted angles and plates. Girders are oriented so that each one supports the wheel loads from one track of the two track rail system. The two inside bascule girders support eighty percent of the rail loading from the two track rail system (RPASCC 1984:14).

The bascule deck is carried on transverse steel purlins that rest on stringers. The stringers span truss-type floorbeams and plate girders. When the bridge is down, live load is supported by the trunion bearings only to a minor extent. The primary bascule girder loads are supported on a live load bearing which is embedded in the concrete bascule pier front wall. A live load anchorage bears on the heel of the bascule girder, controls the resting position of the leaf and supports a portion of the live load (Hardesty & Hanover 1990:7). The positioning of the live load bearing and anchorage are critical elements in the adjustment of the bridge.

Each of the four bascule girders pivots on a forged steel trunion. Every trunion has two bearing surfaces 13 inches long and 13 inches in diameter. Individual trunions are bolted to their girders by collars mounted on each side of the girder. The main trunions rotate in split cast steel bearing housings that are faced with 3/4 inch phosphor bronze bushings on the lower half and 1/2 inch anchored Babbitt metal bushings on the upper half. The bearing housings are supported by a steel framework which bears on stone and concrete piers. The bascule piers are built on a tight knit timber pile pattern. The 30 foot long by 12 inch diameter timber piles are placed 3 feet 6 inches on centers (Wiggin 26 of 36).

In the down position the east and west bascule spans are secured together with four 7 and 7/16 inch forged steel locking bars mounted on the eastern leaf. These fit into cast steel sockets mounted on the western leaf and transfer live load to the opposing leaf. As originally designed and under current operating procedure, the locking bars are electrically actuated. If there is an electrical failure they can be manually operated (see photograph of view of west bascule leaf locking pins in extended position).

All of the measurements and construction details recorded in this document, not otherwise attributed, were taken from plans drafted by the Strauss Bascule Bridge Company or the consulting firm of Ernest W. Wiggin. A complete set of original plans for the bridge, shop drawings for steelwork, architectural details and site plans is preserved at the Connecticut Department of Transportation, 2800 Berlin Turnpike, P.O. Box 317546, Newington, Connecticut 06131.

VI. Personnel

Information on personnel and businesses committed to the project was obtained from the builders plaque. The consulting/designing engineer on the Tomlinson Bridge was Ernest W. Wiggin of New Haven, Connecticut. The City Engineer at the time was Edward S. Nettleton under the direction of John J. Lane, Director of Public Works. W. Vincent Barry was the Bridge Engineer. Steel components of the Tomlinson bridge were fabricated by the Phoenix Bridge Company of Philadelphia, Pennsylvania. On-site assembly, construction and general contracting was completed by C.W. Blakeslee & Sons of New Haven, Connecticut and the New Haven Electric Company.

The designer of the bridge, Joseph Baermann Strauss, was born on January 7, 1870. His career began in 1892 subsequent to receiving his degree in civil engineering from the University of Cincinnati. The first ten years of his career were spent becoming thoroughly familiar with practical aspects of bridge design. The Sanitary District of Chicago employed Strauss to revise and redesign the early types of bascule bridges then being installed. In 1904 he developed the principle of the trunion bascule bridge and founded the Strauss Bascule Bridge Company, later known as the Strauss Engineering Corporation. In 1906 he developed a method of building ribbed concrete arch bridges that did not require the use of false work (temporary supporting structure) during construction.

Strauss produced four types of bascule bridge: the heel trunion, the vertical overhead counterweight, the underneath counterweight and the simple span type. His first underneath counterweight bascule span was the Burnside Bridge in Portland, Oregon. It was 252 feet from trunion center to trunion center and eighty-three feet wide. Strauss also developed a vertical lift bridge that used a rack and pinion drive to replace the more typical operating cables.

Strauss' most distinguished achievement was the Golden Gate Bridge across the mouth of San Francisco Bay. It is generally conceded to be one of the world's most beautiful bridges. He also designed the Arlington Memorial Bridge in Washington, D.C. and was a consulting engineer on The George Washington Bridge and the Bayonne arch (National Cyclopedia 1959:27:30-31).

Those responsible for the selection of Joseph Strauss as the designer may have been influenced by the results of a lawsuit brought by the Strauss Bascule Bridge Company against the city of Chicago. Strauss obtained Patent 995,813 on June 20, 1911. It claimed a number of design improvements, some of which the City of

Chicago had incorporated into bridge designs without obtaining rights from the Strauss Company. Strauss sued, and on October 7, 1919, his patent was conclusively upheld (Baker et. al. 1919:261 F. 358).

The lawsuit had two effects. The judges held Strauss' concept to be "novel, not anticipated and valid" thereby contributing credibility to his ideas and standing as an innovator. The decision enhanced his reputation as an engineer. It also gave notice that Strauss would litigate to protect his inventions and designs.

In view of the lawsuit, it is significant to note that the Tomlinson Bridge blueprints document that Mr. Wiggin, consulting engineer on the Tomlinson bridge project, prudently "obtained a license from the Strauss Company" before proceeding with the job.

VII. Structural Modifications

The present fixed deck has a structural concrete deck slab supporting a concrete ballast in which the railroad ties and tracks are embedded. The deck surface consists of an asphalt overlay. This replaced the original stationary roadway surface of creosote impregnated long leaf yellow pine paving blocks.

The original road surface on the moveable portion of the bridge was made of creosoted Oregon fir planking over trussed and/or solid floor beams. The timber deck was replaced with steel grating in 1947 (Hardesty & Hanover 1990:9).

Since construction, the bridge has undergone major repairs and modifications. In 1943 the four main trunions of the west leaf and one counterweight trunion were replaced. The center locks were repaired and the live load bearings and anchorages adjusted. The original swinging traffic gates were replaced with semaphore type gates (Hardesty & Hanover 1990:9). The bridge has been damaged and closed several times by barges colliding with bridge components. The bridge was rehabilitated between 1973 and 1977. A larger operator's house was installed. The new house was purely functional and not in keeping with the original Beaux-Arts architectural style.

A rehabilitation project which lasted from December of 1973 to August of 1977 cost $2,250,200. During the project new lift machinery was installed and the northeast bascule girder, badly damaged by a cement barge, was replaced. The original counterweight construction failed to meet current US Army Corps of Engineer permit guidelines. Other collision damage prevented the full opening of the bascule leafs. This limited vertical clearance and effectively reduced channel width. Large vessels could not make use of the full 120 foot channel (RPASCC 1984:22).

Part of the counterweight was removed to enable raising the leafs to 78 degrees relative to roadway and 89 degrees relative to the water. Additional weights then had to be spliced on to the counterweight in an attempt to compensate and achieve balance.

The existing fender systems could not fully protect lift spans and a new energy absorbing fender system was installed between September and November of 1977 at a cost of $593,000. Between July of 1983 and May of 1984 deterioration of the counterweights was repaired and the southwest counterweight trunion was replaced (RPASCC 1984:22).

VIII. Recommendation

Subsequent to the replacement of the Tomlinson Bridge, the original plans will continue to be a extremely valuable historical and technological resource. Wiggin's site and architectural drawings, the shop blueprints from the Phoenix Bridge Company and Strauss' detailed mechanical plans on linen are in good condition. The available information is sufficient to build a replica or large scale working model of a Strauss patent bascule. When the drawings are no longer of current engineering interest to CONNDOT, the drawings should be transferred to an archive for preservation and protection.

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Joseph B. Strauss (b. January 7, 1870 - d. May 16, 1938)

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1903 U. S. Patent # 738,954 - Bridge

Strauss, J. B.
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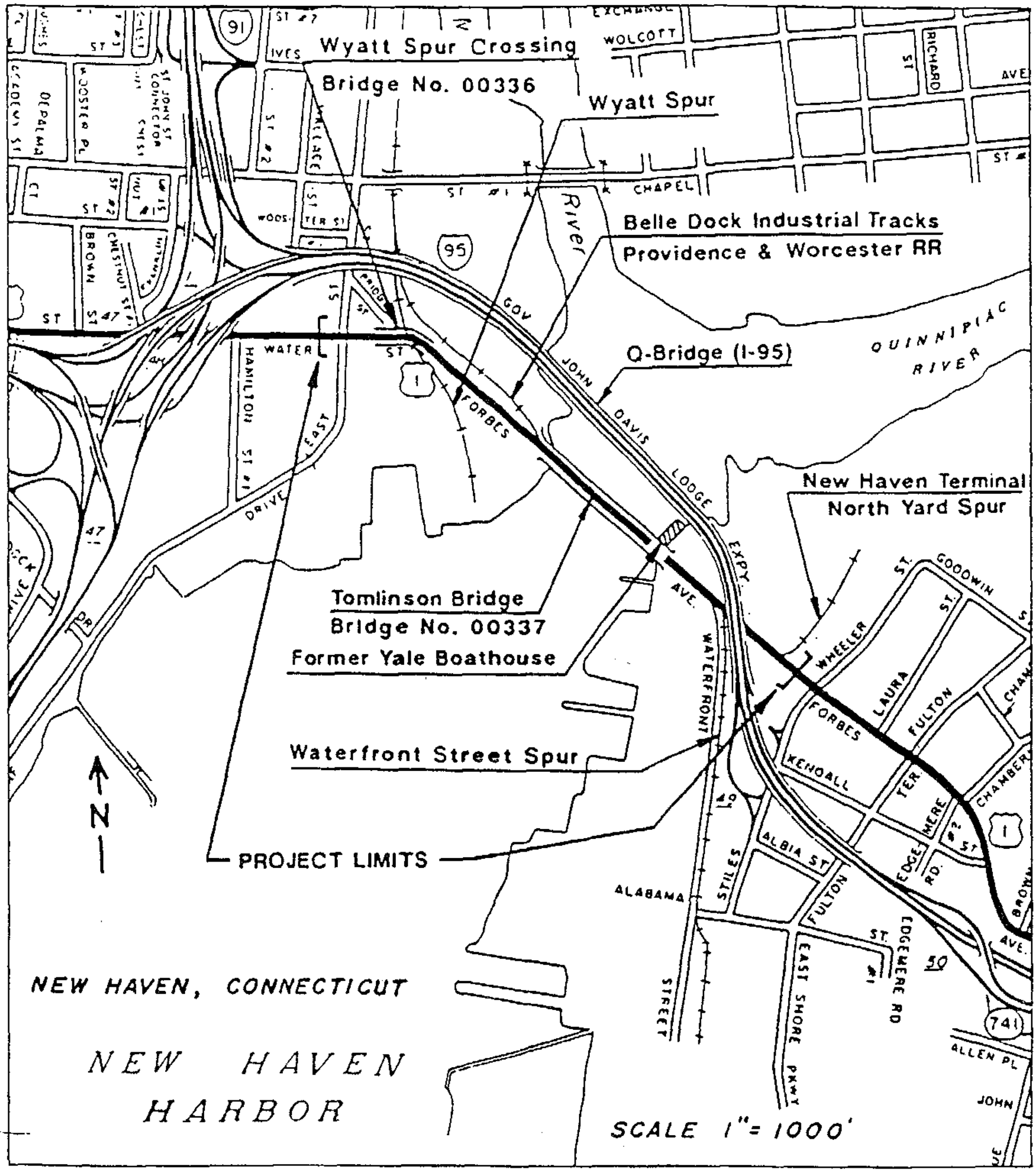
Ernest A. Wiggin, Consulting Engineer
Total of thirty-six sheets-Original plans for Tomlinson Bridge

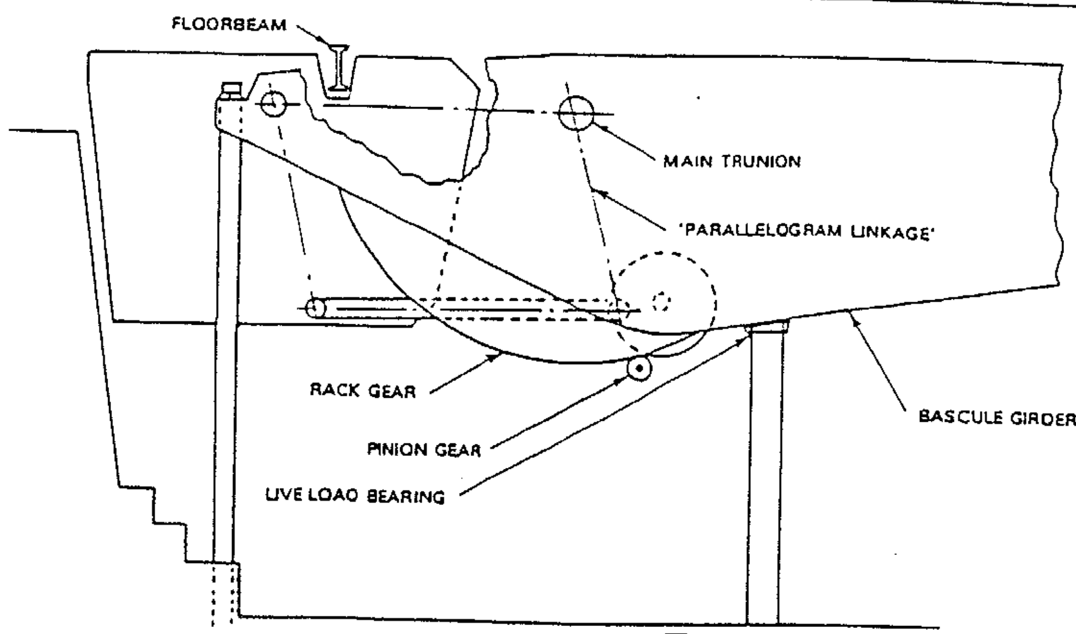
LOCATION MAP

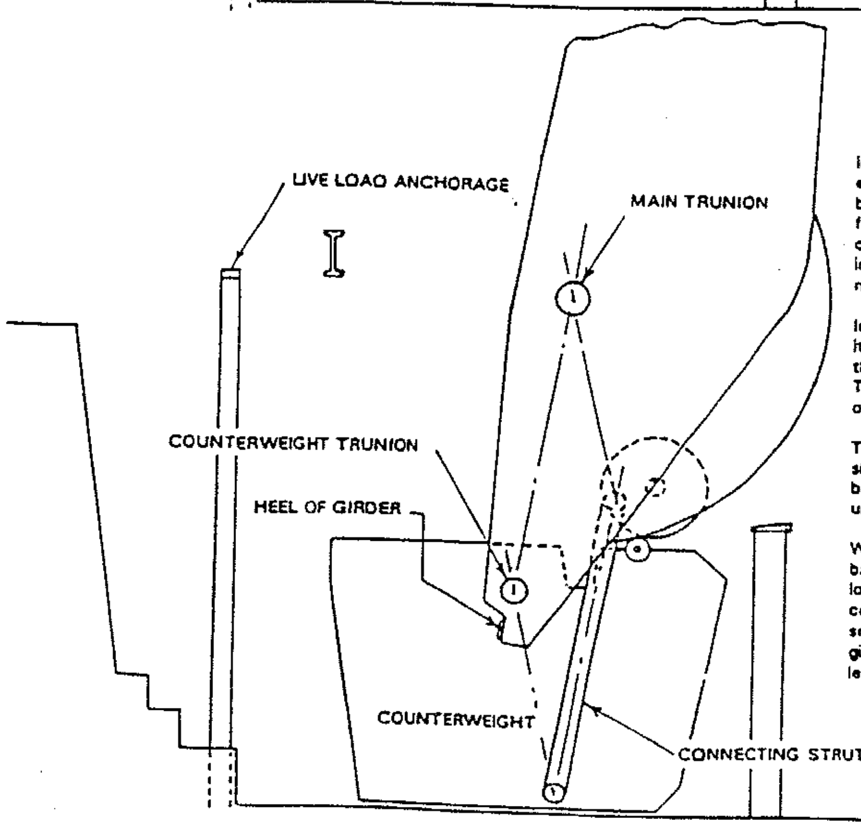
FEBRUARY, 1993
SOURCE: CONNECTICUT DEPARTMENT OF TRANSPORTATION
PROJECT No. 92-435 - F.A.P. No. BRF-1(181)



OPERATING COMPONENTS

SOURCE: ORIGINAL DELINEATED BY ROBERT C. STEWART
BASED ON U.S. PATENTS 738,954 AND 1,124,356
DATE: JUNE 1993





BASCULE OPERATING COMPONENTS

In 1902 Joseph B. Strauss began to develop a series of designs for low cost bascule bridges. Strauss substituted dense concrete filled with slag or iron punchings for the conventional iron counterweights. He invented a linkage system to control movement of the counterweight.

In a parallel link design, the counterweight, its trunion, the main trunion together with their connecting struts, form a parallelogram. The bascule leaf is maintained in a condition of constant balance as it is raised.

To minimize bridge deck height, Strauss shaped the concrete counterweight to fit between the girders and accommodate the upper portion of the counterweight.

When the bridge is down, the primary bascule girder loads are supported on a live load bearing which is embedded in the concrete bascule pier front wall. A live load anchorage bears on the heel of the bascule girder, controls the resting position of the leaf and supports a portion of the live load.

APPENDIX A - PATENT 738,954

SOURCE: U.S. PATENT OFFICE
DATE: SEPTEMBER 15, 1903

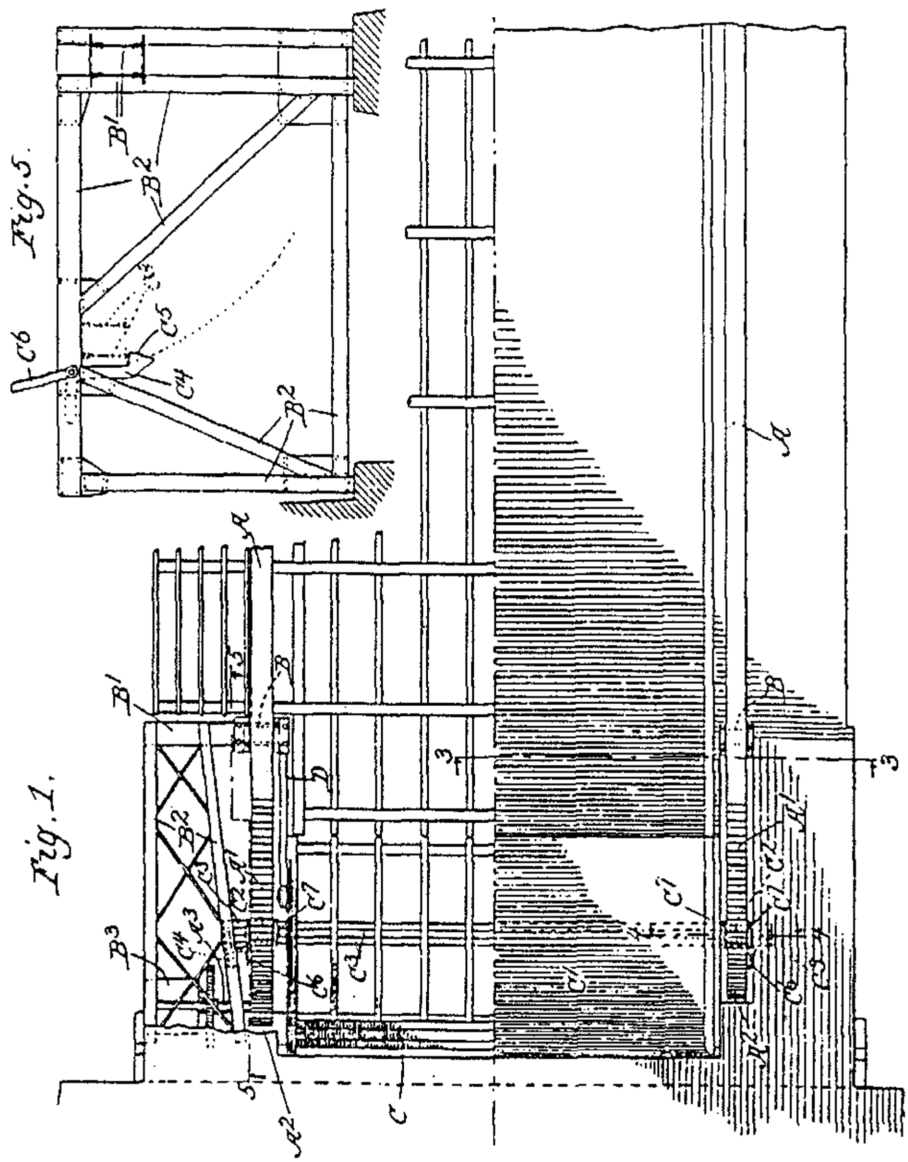
No. 738,954. PATENTED SEPT. 15, 1903.

J. B. STRAUSS.

BRIDGE.

APPLICATION FILED DEC. 19, 1902.

NO MODEL. 5 SHEETS—SHEET 1.



Witnesses.
Edward T. Wray.
Homer L. Kraft

Inventor.
Joseph B. Strauss.
by Parker Carter
Attorneys

No. 738,954. PATENTED SEPT. 15, 1903.

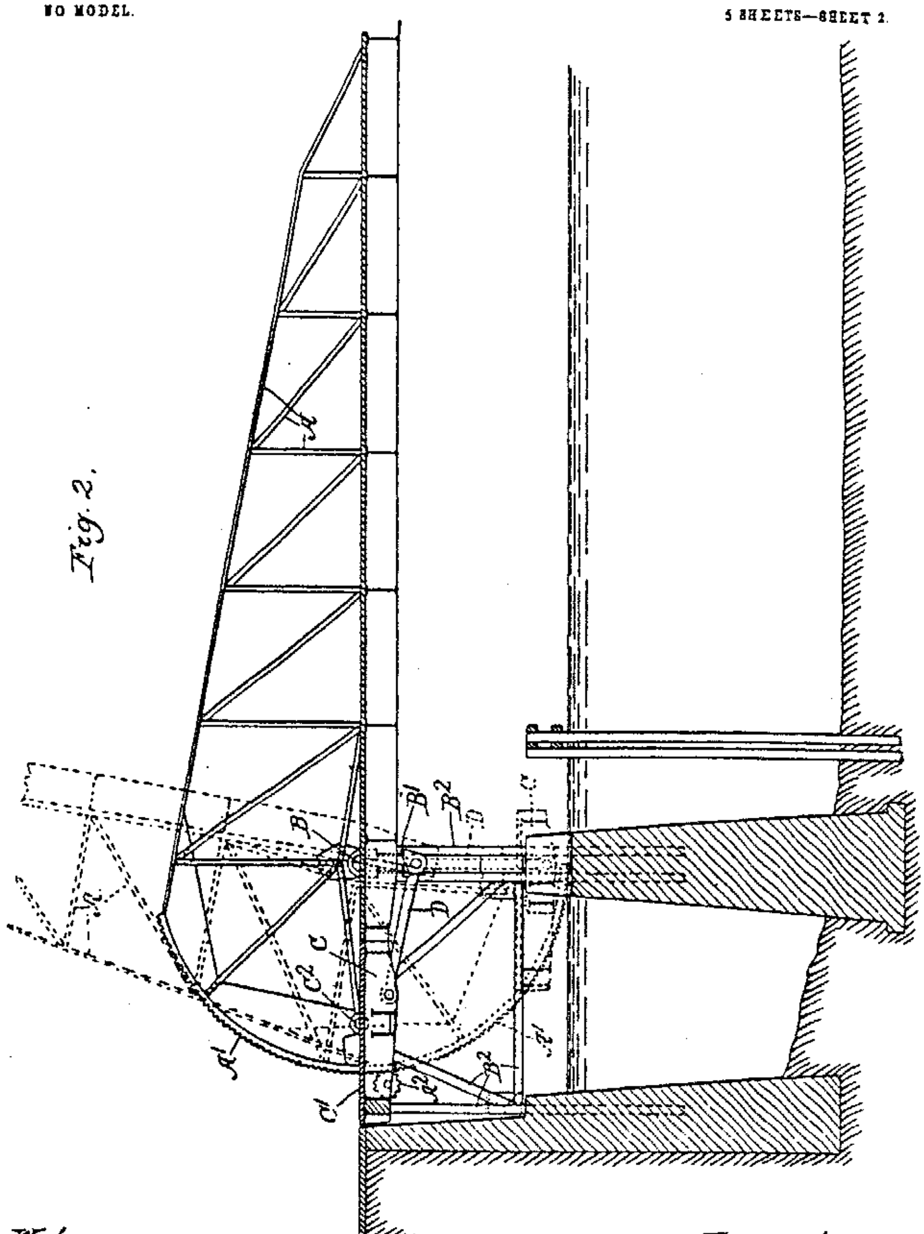
J. B. STRAUSS.

BRIDGE.

APPLICATION FILED DEC. 19, 1902.

NO MODEL. 5 SHEETS—SHEET 2.

Fig. 2.



Witnesses.

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No. 738,954. PATENTED SEPT. 15, 1903.

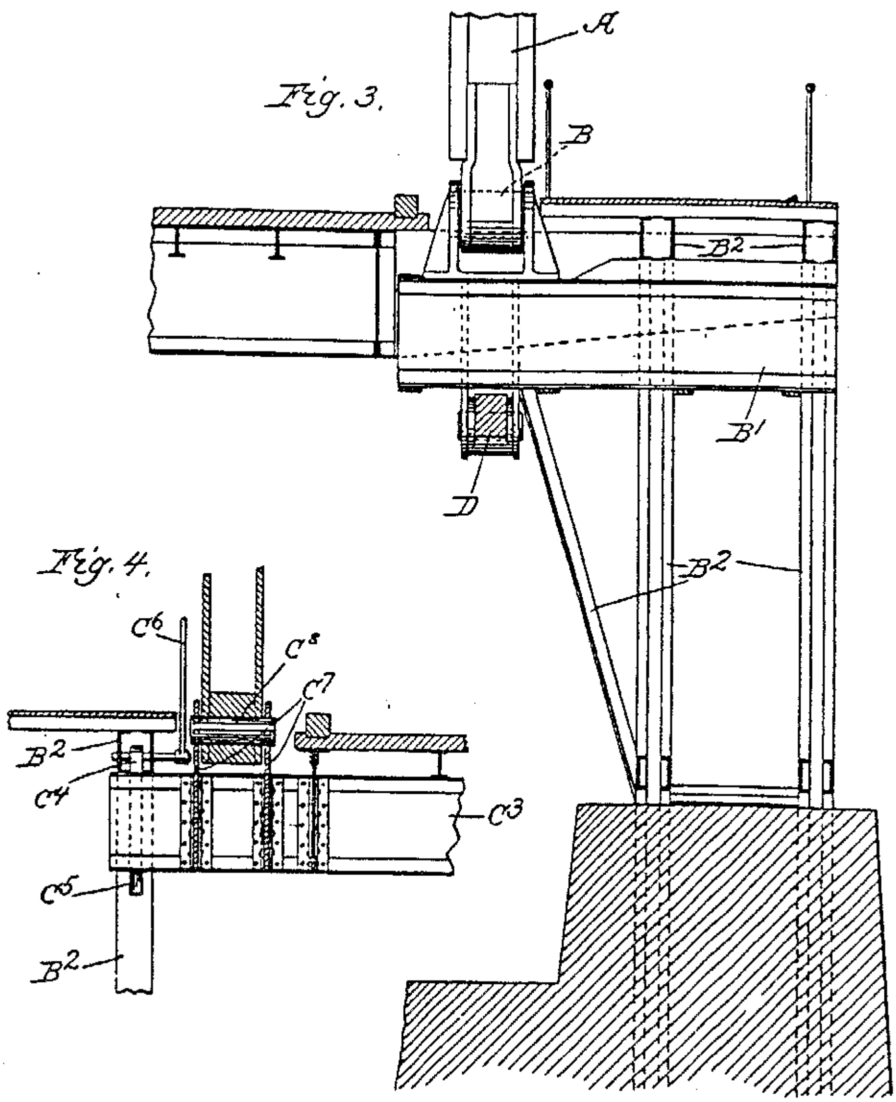
J. B. STRAUSS.

BRIDGE.

APPLICATION FILED DEC. 19, 1902.

NO MODEL. 5 SHEETS—SHEET 3.

Fig. 3.



Witnesses.
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by Parker Carter
Attorneys

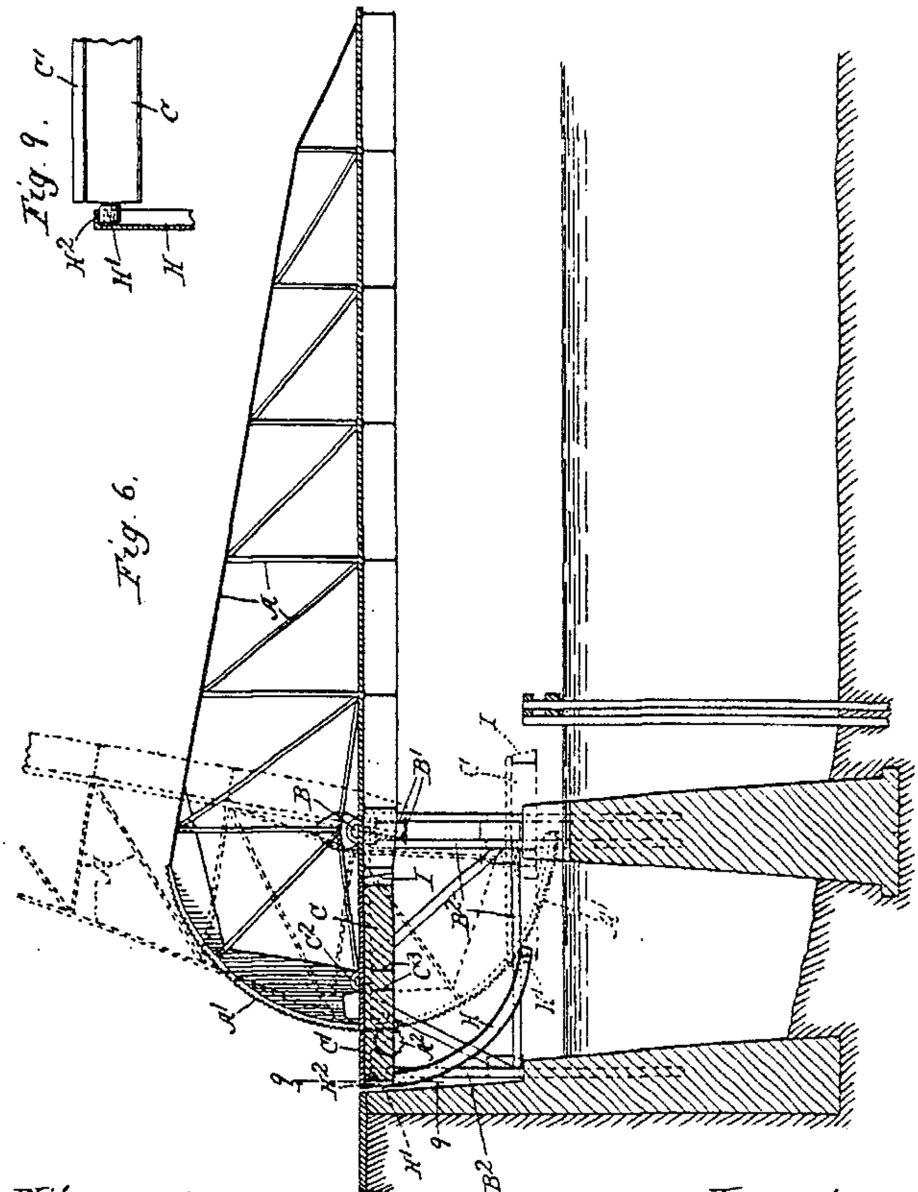
No. 738,954. PATENTED SEPT. 15, 1903.

J. B. STRAUSS.

BRIDGE.

APPLICATION FILED DEC. 19, 1902.

NO MODEL. 6 SHEETS—SHEET 4.



Witnesses.
Edward T. Wray
Howard L. Kraft

Inventor:
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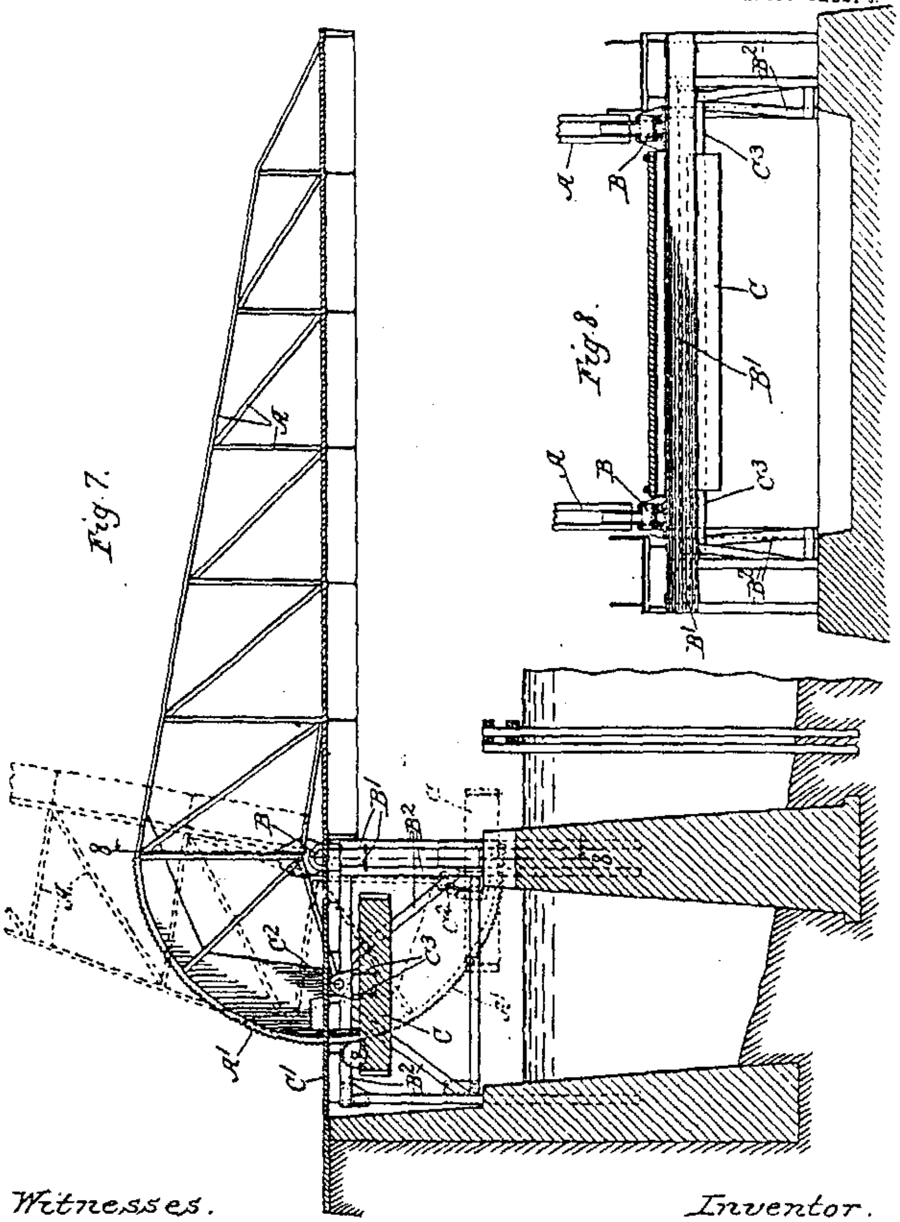
No. 738,954. PATENTED SEPT. 15, 1903.

J. B. STRAUSS.

BRIDGE.

APPLICATION FILED DEC. 19, 1902.

NO MODEL. 5 SHEETS—SHEET 5.



Witnesses.

Edward T. Wray.

Howard L. Kraft

Inventor.

Joseph B. Strauss

by Parker & Carter,

Attorneys.

No. 738,954. Patented September 15, 1903.

UNITED STATES PATENT OFFICE.

JOSEPH B. STRAUSS, OF CHICAGO, ILLINOIS.

BRIDGE.

SPECIFICATION forming part of Letters Patent No. 738,954, dated September 15, 1903.

Application filed December 19, 1902. Serial No. 135,889. (No model.)

To all whom it may concern:

Be it known that I, JOSEPH B. STRAUSS, a citizen of the United States, residing at Chicago, in the county of Cook and State of Illinois, have invented a certain new and useful Improvement in Bridges, of which the following is a specification.

My invention relates to bridges, and has for its object to provide a new and improved bridge, of which the following is a description, reference being had to the accompanying drawings, wherein—

Figure 1 is a plan view with parts omitted of one end of a bridge embodying my invention. Fig. 2 is a vertical section therethrough. Fig. 3 is a section on line 3 3, Fig. 1. Fig. 4 is a section on line 4 4, Fig. 1. Fig. 5 is a section on line 5 5, Fig. 1. Fig. 6 is a vertical sectional view showing a modified construction. Fig. 7 is a similar view showing a further modified construction. Fig. 8 is a section on line 8 8, Fig. 7. Fig. 9 is a detail section on line 9 9, Fig. 6.

Like letters refer to like parts throughout the several figures.

Referring now to Figs. 1 to 5, inclusive, I have shown a construction comprising a main span carried by trusses A A, which are mounted upon trunnions B, carried by a trunnion-supporting piece B′, supported by the frame B^2. There is one of these frames B^2 associated with each of the main trusses. It will be noted that these frames are at one side of the main trusses and that the trunnion-supporting piece projects out over the frame, so that the space beneath the trusses and the main span is free and unobstructed. This is shown clearly in Fig. 3. These frames B^2 may be made in any desired manner. As herein shown, they consist of two frame-pieces, as illustrated in Fig. 5, connected together by suitable cross-pieces and anchored to the masonry. These frames support the controlling mechanism for the main span—such as the electric motor B^3. There is preferably a motor for each truss. The trusses A are provided with the curved racks A′, adapted to be engaged by gears A^2 on the shafts A^3, operatively connected with the electric motors. The counterweight for the main span is pivotally connected thereto at a suitable point, so as to maintain a substantially horizontal position as the main span is raised and lowered, thus very materially shortening the structure and permitting a suitable movement of the counterweight without necessitating the use of a tail-pit, or at least greatly reducing the depth of such tail-pit. As shown in Fig. 2, the counterweight C is connected directly to the approach span C′, and the counterweight and approach span are pivoted to the main trusses at C^2. It is of course evident that any suitable construction may be used for this purpose. As herein shown, the counterweight extends entirely across the floor between the two main trusses, and there is provided a bumping-girder C^3, which extends entirely across between the trusses, the ends projecting beneath the said anchor-frames B^2, as shown in Fig. 4, so that when in their up position further movement is prevented by these frames and the parts are held in position. When the counterweight is attached to the approach span, so that the approach span itself acts either partially or wholly as a counterweight for the main span, I provide a suitable lock for the approach span, so as to hold it in proper position and prevent accidental movement. As herein shown, this locking device consists of a movable locking-arm C^4, attached to the frame B^2 and provided with a beveled face C^5. This locking device is adapted to be engaged by the bumping-girder as it moves up, so as to be moved to one side, and then falls back into position, so as to engage the bumping-girder, and thus holds the approach span in position. This locking device is controlled by means of a lever C^6. The counterweight or the approach span, or both, when they are combined may be pivoted to the trusses in any desired manner. As herein shown, the bumping-girder is provided with projecting parts C^7, which come into proximity to the trusses, and there is a pin C^8 passing through the truss and these projecting parts, as shown in Fig 4, thus securely pivoting them together. As shown in Fig. 2, I have indicated a means for providing an additional increment of efficiency in the counterweight during movement from the open to the closed position of the main span without increasing the short-end lever-arm of the main span, which consists in pivoting it at one side of its center and then connecting to it the struts D, said struts being connected at their other end to a fixed part—as, for example, the trunnion-supporting piece B′—as shown in Fig. 3. It will be seen that by this construction the counterweight may be projected beyond the pivotal point to any degree desired and the parts balanced by the struts D, and thus the leverage of the counterweight increased so as to multiply its effect and at the same time keep it in a substantially horizontal position during the movement of the main span. It will be seen that in this construction when the main span is lifted by means of the operating mechanism the counterweight and the approach span when a part thereof will move down and will keep in a substantially horizontal position, so as to take the position shown in dotted lines in Fig. 2 when the main span is completely open. As ordinarily used the counterweight would be in a substantially vertical position when the main span is open, and the end would thus tip down below the water or into the ordinary tail-pit. By my construction the tail-pit is entirely done away with, or, if used at all, may be very small, and the great cost of the ordinary masonry is thus avoided.

In Fig. 6 I have shown a construction where the approach span acts as a counterweight, and in this construction the approach span is pivotally supported at its center or at or near its center of gravity to the main span, thus giving the entire counterweight the arm equal to the distance between the pivots of the main span and the pivots of the counterweight. With this construction, if the parts are properly made, the counterweight and the approach span will retain a substantially horizontal position during the movement of the main truss and will take the position shown in dotted lines. It will be seen that in this construction the counterweight when the bridge is open projects beneath, or, perhaps, more properly speaking, past, the points of support of the main span, and this necessitates a clear way under the span, which is secured by the construction herein shown and which also may be secured by various other constructions. If desirable, suitable means may be provided for insuring the substantially horizontal position of the counterweight or approach span during all of its positions.

In Fig. 7 I have shown a construction where the counterweight and approach span are separate, the approach span being fixed. In this case the counterweight is pivoted to the main trusses substantially the same as in the other constructions, but is pivoted at its middle or at or near its center of gravity. The counterweight therefore maintains a substantially horizontal position as the main span moves, taking the position shown in dotted lines when the bridge is open. In this construction the trunnion-supporting piece B′ extends entirely across between the frames B². In this construction I secure the beneficial effects of the pivoted counterweight in connection with a bridge having a stationary or fixed approach span.

The construction embodying my present invention provides a bridge where all the moving parts are kept out of the water and where the tail-pit may be eliminated or reduced to very small proportions. The extreme length of the bridge is also very much reduced, and the elimination of the tail-pit in addition to reducing the cost of the structure gives a greater waterway, and thus the bridge does not obstruct the waterway in any material degree.

I have omitted the minor details of the iron construction in the figures in order to simplify the drawings and the drawings are therefore more or less diagrammatic.

I have described in detail particular constructions embodying my invention; but it is of course evident that the parts may be greatly varied in form, construction, and arrangement and that some of the parts may be omitted and others used with parts not herein shown without departing from the spirit of my invention. I do not, therefore, limit myself to the particular construction shown.

It will be seen that by this construction I am enabled to use a short tail end to the main span and that when the main span is closed the counterweight has a part which projects beyond the tail end, this projecting part being varied when the main span rises. In other words, this construction permits me to use a comparatively short tail end and yet to secure a comparatively long lever-arm for the counterweight, the projecting part of the counterweight being withdrawn toward the pivotal point of the main span or toward or within the boundary of the main span as it is lowered, thus permitting me to partially or wholly eliminate the tail-pit.

When the counterweight is provided with the retaining-strut D, it will of course be held in a substantially horizontal position at all times and will not be moved about its pivot due to its unbalanced condition, for with this form of my device the counterweight is always suspended at one side of its center. When the counterweight is suspended in the center, it will ordinarily move down in the proper position; but, if desired, it may be provided with a suitable guide, such as the guide H in Fig. 6. In this construction the counterweight is provided with one or more rollers H′, said rollers working in guideways in the guide H. It will be seen that neither these rollers nor the guide have any strain, for their only function is to keep the counterweight in its balanced position.

When the construction shown in Fig. 2 is used, the struts D hold the approach span in proper position and keep it from tipping when the load passes therealong. When the construction shown, for example, in Fig. 6 is used, it is necessary to provide some means to prevent the approach span from being tipped by the load. This may be accomplished in any desired manner. As shown in said figure, the ends of the main approach spans at the break in the floor are beveled or inclined, as shown at I, so that the approach span cannot be moved up past the level of the floor of the main span. At the other end any suitable device may be used, such as the stop H^2 on the guide H, against which the roller H' strikes when the approach span reaches the limit of its upward movement.

It will be noted that the upward movement of the tail end of the main girders is limited by the engagement of the humping-girder C^3 with the frames B^3, and hence the uplift is carried by these frames. The greater part of the load is then transferred by the diagonal pieces B^2 (see Fig. 5) to the end pieces B^3, to which is connected the beam or girder B', upon which is mounted the trunnions of the main span. It will thus be seen that this uplift is opposed by the load on the trunnions, and anchorage is therefore necessary. The smaller portion of the load is transferred to the abutment, and the only anchorage necessary is that required to take care of this part of the load. It will be seen that by this construction the tail end of the main span when in its normal position engages a part which is connected to the part carrying the load on the main trunnions, and it is this construction which avoids the necessity of providing anchorage for the greater part of the load due to the uplift.

I claim—

1. A bridge comprising a main span, a counterweight therefor pivotally connected to the main span, and means for limiting the movement of the counterweight about its pivot.

2. A bridge comprising a main span, a counterweight connected thereto, and means providing an additional increment of efficiency in the counterweight during movement from the open to the closed position of the main span without increasing the short-end lever-arm.

3. A bridge comprising a main span, pivotally supported between its ends, a horizontally-disposed counterweight movably connected with the short end of the main span, and an engaging device for holding said counterweight in a substantially horizontal position during the movement of the main span.

4. A bridge comprising a main span, mounted upon trunnions, supporting parts for said trunnions, an open way between said supporting parts, a horizontally-disposed counterweight connected with said main span, a portion of said counterweight passing by the trunnion-supports when the main span is open.

5. A bridge comprising a main span, provided with a series of main trusses, a beam or girder extending across the space between at least two of them, and a counterweight for said main span extending across between at least two of said main trusses and connected to said beam or girder.

6. A bridge comprising a main span, provided with a series of main trusses, and a counterweight for said main span extending across between at least two of said main trusses, said counterweight pivotally connected to said trusses.

7. A bridge comprising a main span, provided with a series of main trusses, a beam or girder at the tail end of said trusses extending across the space between them and pivotally connected thereto, and a counterweight attached to said beam or girder.

8. A bridge comprising a main span, provided with a series of main trusses, a beam or girder at the tail end of said trusses extending across the space between them and pivotally connected thereto, a counterweight attached to said beam or girder, and means for keeping said counterweight in substantially the same relative position during all the positions of the main span.

9. A bridge comprising a main span, a counterweight movably connected to said main span at one side of its center, and means for preventing movement of the counterweight due to its unbalanced condition.

10. A bridge comprising a pivotally-supported main span, a counterweight pivoted at one side of its center to said main span, so as to be in an unbalanced condition, and a retaining-strut connected to the short arm of the counterweight and to a fixed part so as to prevent displacement due to the unbalanced condition, whereby the effect of the counterweight is increased.

11. A bridge comprising a main span, supporting parts therefor, a counterweight attached to said main span, and an open way between the supports for the main span whereby the counterweight may pass between said supports.

12. A bridge comprising a main span, an approach span pivotally connected to said main span so as to move therewith, said approach span acting partially or wholly as the counterweight for the main span.

13. A bridge comprising a main span, an approach span pivotally connected to said main span so as to move therewith, said approach span acting partially or wholly as the counterweight for the main span, and a fixed engaging part adapted to engage said approach span so as to limit its upward movement.

14. A bridge comprising a main span, an approach span pivotally connected to said main span so as to move therewith, said approach span acting partially or wholly as the counterweight for the main span, and a locking device for locking the parts in their normal position.

15. A bridge comprising a main span, provided with main trusses, a cross-piece pivotally connected to the tail end of said main trusses, and an approach span carried by said cross-piece so as to move with the main span.

16. A bridge comprising a main span, sup-

ports for said main span located outside of the boundary of the main span so that the space between said supports is free.

17. A bridge comprising a main span, supports for said main span located outside of the boundary of the main span so that the space between said supports is free, and a horizontally-disposed counterweight pivotally connected to the tail end of said main span and adapted to pass between said supports when the main span is lifted.

18. A bridge comprising a pivoted main span having a tail end, a comparatively thin horizontally-extending counterweight attached thereto, and having a part which projects beyond said tail end, and means for varying the length of this projecting part as the main span rises.

19. A bridge comprising a comparatively thin horizontally-extending counterweight which projects beyond the tail end of the main span when the bridge is closed, and means for drawing the projecting end of said counterweight toward the pivotal point of the main span as the span is raised.

20. A bridge comprising a main span, a support therefor, a part for limiting the upward movement of the tail end of the main span and which receives the uplift, said part connected with the support for the main span whereby a portion of the uplift is counteracted by the main load.

JOSEPH B. STRAUSS.

Witnesses:

DONALD M. CARTER,

EDWARD T. WRAY.

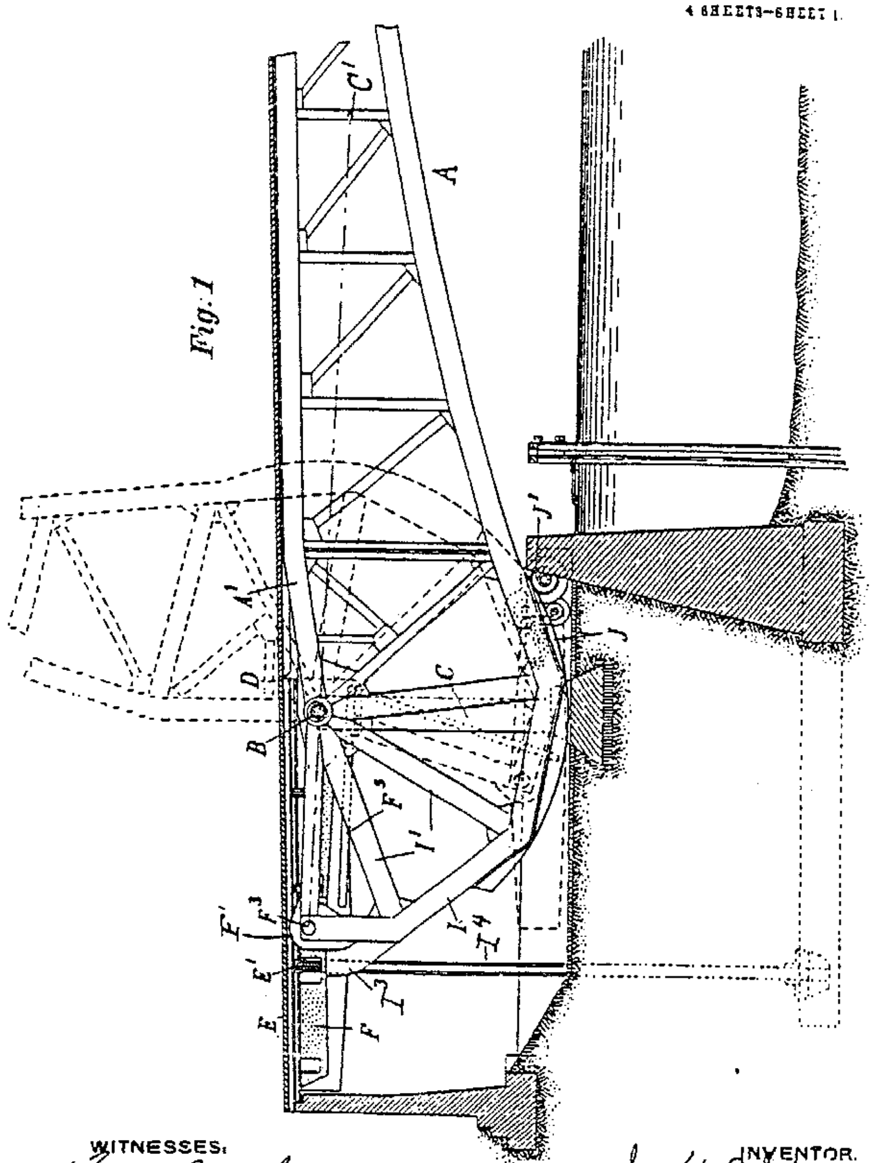
APPENDIX B - PATENT 1,124,356

SOURCE: U.S. PATENT OFFICE
DATE: JANUARY 12, 1915

J. B. STRAUSS.
BASCULE BRIDGE.
APPLICATION FILED FEB. 19, 1906.

1,124,356. Patented Jan. 12, 1915.

4 SHEETS—SHEET 1.



WITNESSES:
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ATTORNEYS

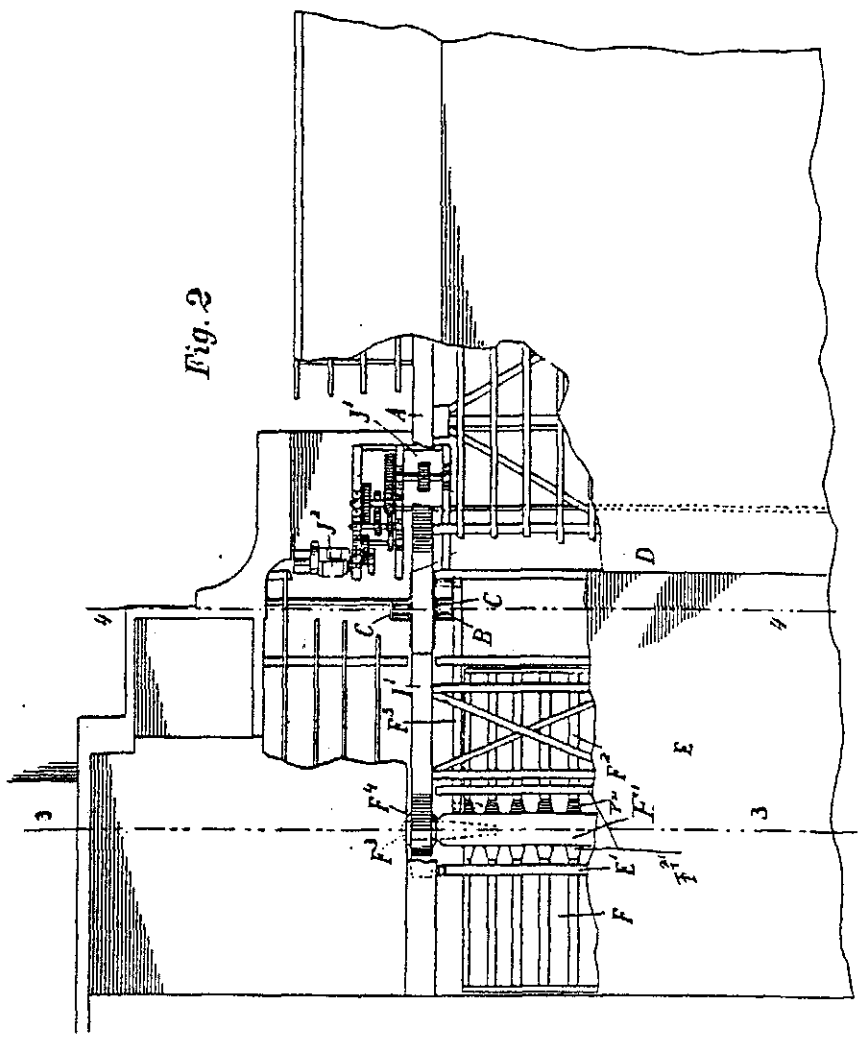
J. B. STRAUSS.
BASCULE BRIDGE.
APPLICATION FILED FEB. 19, 1906.

1,124,356.

Patented Jan. 12, 1915.

4 SHEETS—SHEET 2.

Fig. 2



WITNESSES:
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J. B. STRAUSS.
BASCULE BRIDGE.
APPLICATION FILED FEB. 19, 1906.

1,124,356. Patented Jan. 12, 1915.

4 SHEETS—SHEET 3.

Fig. 3

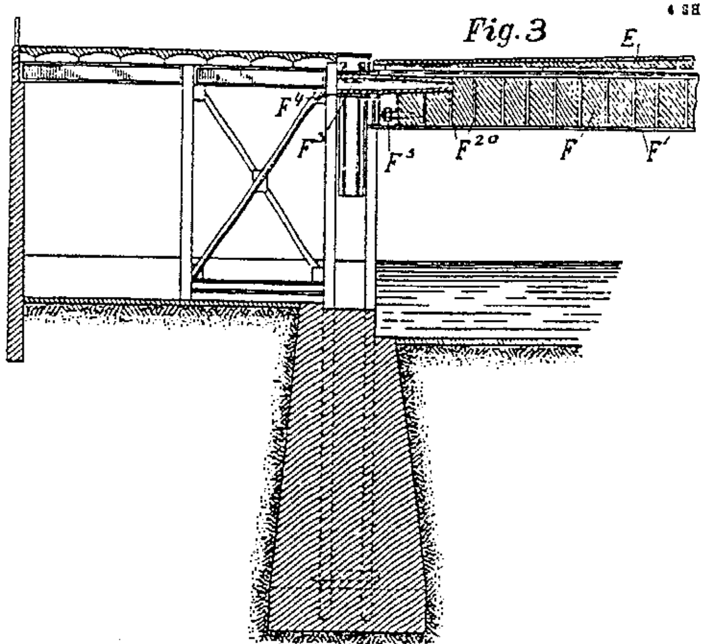
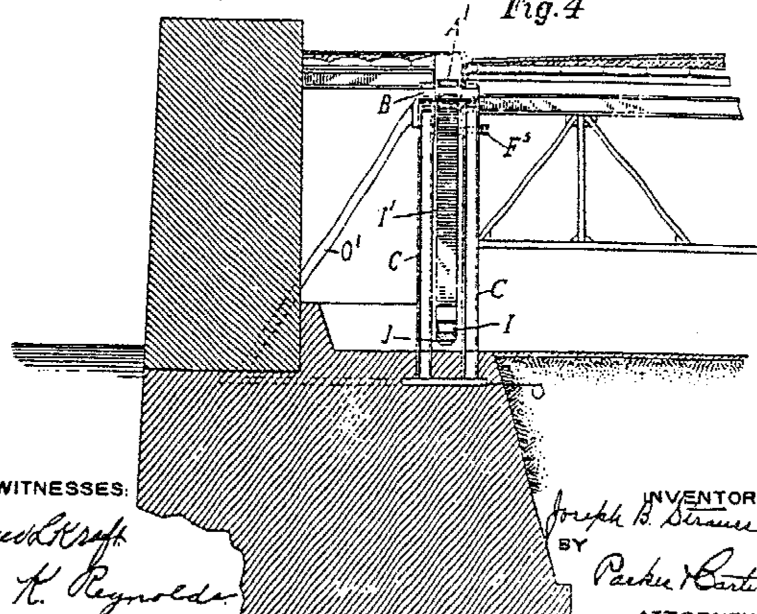


Fig. 4



WITNESSES:
Howard L. Kraft
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J. B. STRAUSS.
BASCULE BRIDGE.
APPLICATION FILED FEB. 19, 1906.

1,124,356. Patented Jan. 12, 1915.

4 SHEETS—SHEET 4.

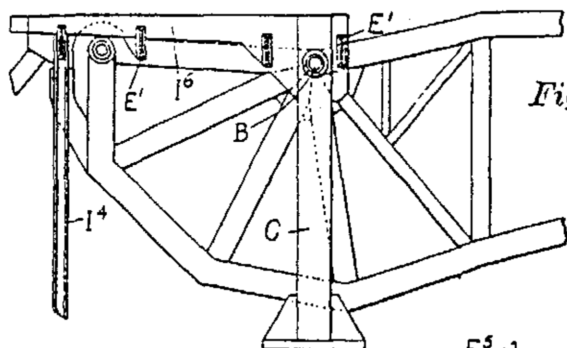

Fig.5

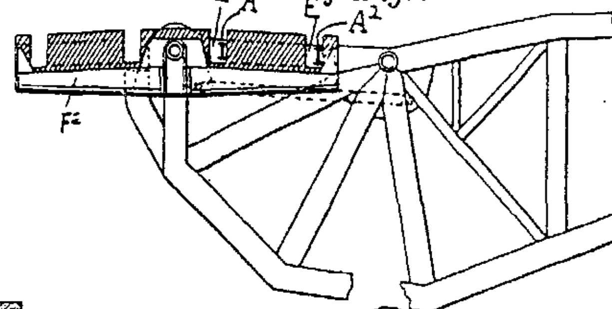

Fig.6

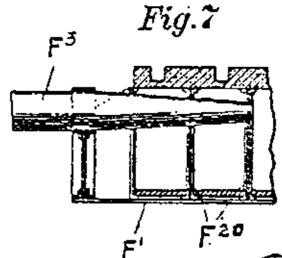

Fig.7

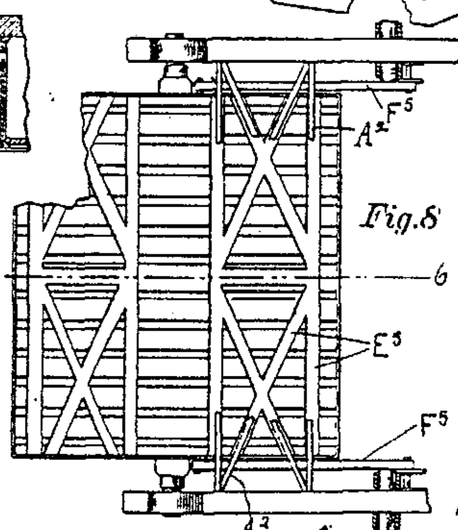

Fig.8

WITNESSES:
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by Parker & Carter
attys.

UNITED STATES PATENT OFFICE.

JOSEPH B. STRAUSS, OF CHICAGO, ILLINOIS, ASSIGNOR TO THE STRAUSS BASCULE AND CONCRETE BRIDGE COMPANY, OF CHICAGO, ILLINOIS, A CORPORATION OF ILLINOIS.

BASCULE-BRIDGE.

1,124,356. Specification of Letters Patent. Patented Jan. 12, 1915.

Application filed February 19, 1906. Serial No. 301,773.

To all whom it may concern:

Be it known that I, JOSEPH B. STRAUSS, a citizen of the United States, residing at Chicago, in the county of Cook and State of Illinois, have invented a certain new and useful Improvement in Bascule-Bridges, of which the following is a specification.

My invention relates to bascule bridges, and has for its object to provide a new and improved bridge of this description.

My invention is illustrated in the accompanying drawings, wherein—

Figure 1 is a side elevation in part section illustrating my invention; Figure 2 is a plan view with parts broken away; Fig. 3 is a sectional view taken on line 3—3 of Fig. 2; Fig. 4 is a sectional view on line 4—4 of Fig. 2. Fig. 5 is a view showing the support for the main span illustrating the members for the upward and downward forces. Fig. 6 is a sectional view through the counterweight taken on line 6—6 of Fig. 8 showing the grooves of the counterweight material. Fig. 7 is a sectional view through that part of the counterweight where the counterweight pin is located. Fig. 8 is a plan view of the counterweight.

Like letters refer to like parts throughout the several figures.

This invention has among other objects to provide what may be called an underneath type of structure wherein the bridge, counterweight and the operating mechanism are all beneath the roadway.

In the drawings I have shown one span of the bridge. It is, of course, evident that the bridge may be a single span bridge or there may be two spans, one on each side of the stream, the two connected together at the middle when in their operative position.

As shown in the drawings, a main span A comprising suitable trusses A^1 is mounted upon suitable trunnions, or projecting pins B which work in bearings in the supporting posts C, C, said trusses passing in between said supporting posts as shown. The trusses A^1 are connected together by the cross pieces A^2. (See Fig. 4.) By this arrangement it will be seen that the supporting posts are symmetrically disposed with relation to the trunnions. There is also suitable bracing for said posts. The floor D of the main span does not extend all the way along said main span, but stops at the point at one side of the trunnions. The rest of the floor E back to the abutment wall is fixed. The counterweight F is located beneath the roadway floor E and may be made up in any desired manner. As herein shown it consists of a main central cross girder F^1 and longitudinal girders F^2 (see Fig. 2). The main cross girder is a box girder having interior webs or diaphragms F^{10} (see Fig. 7) at right angles to the axis of the girder. The longitudinal girders are divided into two sections, the ends of which abut the cross girders and which are fastened thereto by the plates F^{11}. At each side of the counterweight there is a counterweight pin F^3 cantalivered in the main cross girder (see Figs. 2 and 7) said pin passing through holes in the diaphragms F^{10} and connecting to a plurality of said diaphragms so that the pin reactions are transmitted to the main cross girder. These pins project beyond the counterweight into suitable bearings F^4 in the trusses. (See Fig. 3.) It will be seen that by this construction the counterweight is, as it were, concentrated at the points where the pins are connected with the main cross girder and is free to move with relation to the trusses so that the counterweight can keep its horizontal position. The counterweight pin and the trunnion of the main span are in line with the center of gravity of the main span. This will be seen in Fig. 1 where the center of gravity is diagrammatically represented at C^1. A suitable floor is preferably associated with the counterweight girders. The counterweight is preferably cut away so as to receive the cross beams or stringers E^1 of the roadway floor when the bridge is down so that there would be no interference between the roadway floor and the counterweight. This is illustrated more clearly in Figs. 6 and 8 wherein the counterweight is shown as provided with cut away portions or grooves E^2, the beams or stringers being omitted in Fig. 8 to show these grooves. By this construction the counterweight extends toward the roadway floor between the stringers supporting said floor. Connected with the counterweight is a counterweight link F^5 which is pivoted to the counterweight and to the fixed support. This keeps the counterweight in a proper horizontal position during all the various positions of the main span.

The rear end of the main span instead of being made up of curved members is composed of a series of straight members or chords of a circle I and radial members I^1

from the trunnion to the intersecting points of said chords (see Fig. 1).

Any suitable operating mechanism may be used for raising and lowering the main span. As herein shown the main span is provided with a toothed rack J which is engaged by a gear wheel J^1 connected by suitable reducing gears to a motor J^2. This rack and the operating mechanism are beneath the roadway floor so as to be out of the way. When the bridge is in its operative position the parts are as shown in full lines in Fig. 1. When it is desired to lift the bridge the operating mechanism is started and the main span moved about the trunnions as pivots. The counterweight moves down with the rear end of the main span, said rear end moving away from the fixed roadway floor, the counterweight keeping in a horizontal position and assuming the position shown in dotted lines when the bridge is up. When the bridge is again lowered the parts take the position shown in full lines. It will be seen by this construction that all the parts and operating mechanism are beneath the roadway so that there are no upwardly projecting parts or mechanism.

It will be noticed that the fixed floor, the fixed support, the rear end and the counterweight are all adapted to work in the limited space between the underside of the roadway and the water line. The various parts are therefore recessed and otherwise adapted to fit into and clear each other during the operation of the bridge.

The fixed supports on which the trunnions are mounted and which are arranged in pairs, are so arranged with relation to the counterweight that part of the counterweight passes by them and in front thereof when the bridge is open. Said fixed supports or supporting posts are mounted upon bolsters O, there being side braces O^1 for said supporting posts also connected with said bolsters, the supporting posts, braces and bolsters acting as a unit. The movable section of the bridge is provided with main trusses, said main trusses having the trunnions associated therewith and provided with radial members radiating from the trunnions in straight lines toward the front and rear. The main span is provided with what may be called a double rear end member consisting of a member upon which the counterweight pins are mounted and the member acting as a bumper, and the counterweight pin is in one line of action and the bumper I in the other, the bumper acting at the rear of the counterweight pin. This bumper stops the main span when it has reached its lowered position by engagement with the stringer E^1 anchored by the members I^4, and holds it in place. The pressure of this bumper is resisted by the members I^4 which are properly anchored in any desired manner. The fixed floor and the main span have a joint support, that is, they are supported upon the same device. The support for the main span embraces members for the upward and downward forces with suitable connections between them. These members and connections are shown in Figs. 1 and 5. The members for the upward and downward forces consist of the posts C and the members I^4. The connection between these members is obscured by the truss and counterweight in Fig. 1, but is clearly shown in Fig. 5, and consists of the connecting piece I^5, there being one of these at each side of the bridge.

The counterweight pins upon which the counterweight is supported are located in substantially the same horizontal plane as the center of gravity of the counterweight. The support for the main span embraces direct acting vertical supporting members for the upward and downward forces in a vertical plane with the trunnions and bumper and suitable horizontal bracing between them, the horizontal bracing consisting of the floor and floor beams at the top.

I claim:

1. A bascule bridge comprising a main span, two sections of floor, one attached to the main span, the other free therefrom but fixed in position and extending over the rear end of the main span, a counterweight attached to the rear end of the main span and disposed to fit between the cross supports of the fixed floor and beneath it.

2. A bascule bridge comprising a main span mounted upon trunnions, a counterweight therefor comprising cross and longitudinal girders, a floor associated with said girders carrying the counterweight material, counterweight pins cantalivered in the main cross girder and projecting beyond the counterweight, said pins working in bearings on the main span.

3. In a bascule bridge a fixed floor, a counterweight movable with relation to said fixed floor comprising a supporting frame, counterweight material supported in said frame and extending above said frame and toward the fixed floor, said counterweight material recessed to receive the supports of said floor.

4. In a bascule bridge a main span mounted upon supports so as to be opened and closed, a counterweight connected with said main span, a fixed roadway floor above the counterweight having a supporting floor system to receive said counterweight when the main span is in its closed position and arranged so that a part of the floor system and counterweight are in the same horizontal plane when the main span is closed.

5. A bascule bridge comprising a main span, a counterweight frame comprising a main cross girder and longitudinal girders,

said cross girder acting as a main support for the longitudinal girders and provided with a plurality of separated diaphragms and pins at the ends of said cross girder for connection with the main span, each of said pins having a bearing in a plurality of said diaphragms, said pins having bearing ends projecting beyond the cross girder.

6. In a bascule bridge a main cross girder provided with a plurality of separated diaphragms and having pins at its ends, each of said pins having a bearing in a plurality of said diaphragms, said pins having bearing ends which project from the girder.

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Witnesses:
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